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(54) **HIGH PERFORMANCE ACOUSTICAL CLEANING APPARATUS FOR TEETH**
AKUSTISCHES HOCHLEISTUNGSZAHNPUTZGERÄT
APPAREIL DE NETTOYAGE DENTAIRE ACOUSTIQUE DE HAUTE PERFORMANCE

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Description

Technical Field

[0001] This invention relates generally to dental hygiene devices and more specifically concerns a power-driven acoustic toothbrush having a selected range of bristle tip velocities so as to produce high performance results.

Background of the Invention

[0002] Conventional toothbrushes, including both manual and power-driven embodiments, attempt to produce the desired cleansing effect by scrubbing the surfaces of the teeth to remove dental plaque. Flossing is typically recommended in addition to brushing to reach those tooth areas which cannot be reached by a brush.

[0003] However, it is well-known that flossing is inconvenient and difficult to perform. Consequently, only about 15% of the population practice flossing regularly. In addition, conventional brushing action, particularly over an extended period of time, can result in an undesirable wear on teeth surfaces.

[0004] In order to improve on the bushing/flossing combination, a number of different technical approaches have been used, with varying success. A first category or group of devices involves the water jet phenomenon. Representative examples of patents in this group include US-A-3,227,158 to Moret, and US-A-3,522,801 to Robinson. Typically, these devices use a pulsating, highly directed stream of fluid to remove material from around the teeth. However, these devices do have significant disadvantages, including a requirement of relatively high water pressure. Generally, these devices are not very effective in removing plaque. In addition, bacteremia sometimes results from use of these devices. Further, a water jet device is powered by line voltage (not batteries), and typically requires a significant amount of shelf space.

[0005] A second group of devices includes those in which a brush is vibrated at an ultrasonic frequency rate to product a cavitation effect which in turn results in the desired cleansing. US-A-3,335,443 to Parisi and US-A-3,809,977 to Balamuth are examples of such devices. The primary difficulty with such devices is the requirement of providing energy through the bristles at ultrasonic frequencies, which are substantially higher than the resonant frequency of the bristles, resulting in very low efficiency of energy transfer to the tips of the applicator. Safety problems may also be significant with such devices, due to the application of ultrasonic energy to tissue.

[0006] In still another group are devices which operate at low sonic frequencies but which also allegedly produce a cavitation effect. US-A-3,535,726 and US-A-3,676,218, both to Sawyer, are representative of this group. It is questionable, however, that a vaporous cavitation effect is actually produced by these devices, particularly for those which are hand held and indicated to be powered by batteries.

[0007] Lastly, some devices operate in the low audio frequency range (200-500 Hz), and produce what is characterised as mild cavitation, combining that effect with conventional bristle scrubbing action to achieve cleansing. One example of such a device is shown in US-A-4,787,747 (upon which the preamble of indepent claims 1, 12 and 14 is based). to Martin et al. This device is effective at least to some extent in disrupting plaque colonies. However, the "cavitation" produced by this device, which in fact is not vaporous cavitation (vaporous cavitation being often referred to as "true" cavitation) does not extend beyond the tips of the bristles, and therefore the device is not particularly effective in the inter-dental and subgingival areas of the teeth where enhanced cleansing is needed. Another example of this group of devices is the subject of Wo 92/16160 which is part of the state of the art in the context of the present application under the provisions of Article 54(3) EPC. It is a vibrating toothbrush which includes a toothbrush body and a lever arm having toothbrush bristles at one end thereof. The lever arm is mounted for pivotal movement at a pivot member which is in the vicinity of the other end of the lever arm. A pair of permanent magnets are provided at the other end of the lever arm, positioned side-by-side with opposite polarities. An electromagnet is provided at the rear of the lever arm. The electromagnet includes an E-core having top, bottom and centre legs with a coil wound around its centre leg which receives an alternating current driving signal from an oscillator/battery section. The frequency of operation is in the range of 150-400 Hz. The action of the alternating current in the electromagnet causes the lever arm to move about the pivot member, first in one direction and then in an opposing direction to provide the desired vibrating effect.

[0008] Accordingly, there remains a need for a toothbrush device which has a significant cleaning effect beyond the tips of the bristles, reaching important areas such as the interdental and subgingival regions, yet is safe as well as convenient to use.

Disclosure of the Invention

[0009] Accordingly, the invention is a dental hygiene device and a method for cleaning teeth and interdental and gingival areas according to claims 1 to 19.

Brief Description of the Drawings

[0010]

Figure 1 is a side elevational view of the toothbrush of the present invention, showing the basic elements of the toothbrush.

Figure 2 is a top plan view of the toothbrush of Fig-

ure 1.

Figure 3 is a top plan view showing the bristles of the toothbrush of the present invention in position relative to two adjacent teeth.

Figure 4 is a side elevational view showing the action of the bristles of the toothbrush of the present invention relative to dental fluid and the teeth being cleaned.

Figure 5 is a schematic view showing the effect of bristle action of the present invention on teeth bacteria.

Figure 6 is a diagram showing the relationship of shear stress on bacteria present on teeth and the rate of dislodgement of the bacteria from the teeth.

Figure 7 is a top plan view showing the effect of bristle action of the toothbrush device of the present invention using a dental fluid.

Figure 8 is a diagram showing critical parameters of frequency and amplitude for the toothbrush of the present invention.

Figure 9 is an isometric view of a toothbrush of the present invention having a rotational brush action.

Best Mode for Carrying out the Invention

[0011] Figures 1 and 2 show the toothbrush of the present invention, generally at 10. The operational effect of the toothbrush, as described hereinafter, is that, by using selected bristle frequency and amplitude ranges, a significant cleansing effect is produced beyond the tips of the bristles, reaching into interdental and subgingival regions, through a layer of dental fluid, to bacterial plaque on the teeth. This effect is in addition to the conventional scrubbing effect produced by the motion of the bristles when they are in actual physical contact with the teeth to be cleaned.

[0012] The toothbrush 10 includes a body 12 which in turn includes a handle portion 14. An electromagnet 16, which comprises a stack of E-shaped laminations 18 with a coil 20 positioned around the middle leg 22 of the stack of laminations, is mounted within handle 14. Coil 20 is driven by a conventional square wave oscillator, shown generally at 24, which is mounted on a printed circuit board 26 and driven by two AA size batteries 28 in the particular embodiment shown. It should be understood, however, that other driving circuitry could be used. The free end tips 30-30 of the stack of laminations 18 are positioned 1-2 mm away from one end 31 of a resonator arm 32. A pair of permanent magnets 34-35 are mounted on a back iron member 36 which is attached to the one end 31 of resonator arm 32. In the embodiment shown, the permanent magnets are made from neodymium iron boron and are mounted in opposite polarities on the flat back iron member 36. Member 36, in operation, closes the magnetic flux path between electromagnet 16 and the two permanent magnets 34 and 35.

[0013] Resonator arm 32 is an elongated steel member, mounted by means of a steel torsion pin 38 to body 12 of the toothbrush. Resonator arm 32 is fixedly secured to torsion pin 38, the ends of which are affixed to a circular collar 40 attached to the body 12. The diameter and length of the torsion pin 38 are selected to provide a spring constant which resonates with the mass and compliance distribution of the remainder of the resonator arm. The resonant frequency of the torsion pin is close to the drive frequency of the apparatus, e.g. 250 Hz. In operation, arm 32 twists the torsion pin 38, with the torsion pin tending to maintain the resonator arm in a center position.

[0014] At the other end 44 of resonator arm 32 is a brush head 46. The bristles 47 on the brush head 46 in the embodiment shown are made of and are approximately 0.15-0.2 mm in diameter, and the tips are formed into a scalloped pattern, as shown most clearly in Figure 1, such that the bristle tips fit into the interdental crevices between teeth. There is typically a distance of 5-8 mm between successive peaks of the scalloped tips and a distance of approximately 1.5-3 mm between the tallest and shortest bristles. In operation, the brush of Figures 1 and 2 oscillates in an approximate sinusoidal pattern, linearly back and forth about pin 38, within particular frequency and amplitude ranges. The bristle tip position can be described by the following formula: $X(t) = X_0 \sin(2\pi ft)$, where X is bristle tip position, X_0 is the amplitude of oscillation, f is the frequency of oscillation in Hz, and t is time. The bristle velocity U(t) has a peak value of $X_0 2\pi f$. Operating parameters, which are discussed in more detail hereinafter, include combinations of amplitudes of up to ± 6 mm and frequencies up to 500 Hz, the product of which exceeds a critical value. At typical values of amplitude (2.5 mm) and frequency (250 Hz), the instantaneous velocity of the bristle tips is 3.9 m/s.

[0015] Figure 9 shows a toothbrush similar in effect to that of Figures 1 and 2, except that shaft 93 rotates, by action of motor 94, which is mounted in a body 95. Motor 94 rotates shaft 93 about its major axis 96 through an angle ± Θ (rad.). If the bristle tips are driven at frequencies well below their resonant frequency, the tips move through an arc length of ± Θ Rb, where Rb is the distance from the free end of the bristles to the axis of rotation 96. When the tips of the bristles are driven at a frequency near the resonant frequency of the bristles, the tips of the bristles move through a larger arc than that provided by the above formula. The movement of the bristles, whether it be linear as for the embodiment of Figures 1 and 2, or through an arc, as for Figure 9, or for some other periodic back and forth reciprocal movement, is generally referred to herein as oscillating movement.

[0016] In actual use of the brush 10, as shown representationally in Figure 3, the toothbrush is held so that the brush head 46 is approximately horizontal, with the tips 49 of the bristles 47 positioned against the side surfaces of the teeth 50, typically near the gum line. As

indicated above, the bristles 47 fit around adjacent teeth, into the front portions of the interdental regions between teeth 50. The motion of the brush is up and down, i.e. linearly into and out of Figure 3, toward and away from the gumline.

[0017] Figure 4 shows the action of bristles 52 of a toothbrush of the present invention in relation to a representative tooth 53, a gum region 54, and a mass of dental fluid 56. As a result of the action of the bristles, pressure in the fluid 56 surrounding the teeth builds up, especially in the area where the gum region 54 meets the teeth. The pressure will reverse, resulting in an alternating pressure field, as the brush sweeps first in one direction and then the opposite direction. The pressure is concentrated on periodontal pocket 60 between the gum region and the tooth, where bacteria are concentrated. The sweeping, back and forth motion of the bristles, towards and away from the gum line, causes the fluid 56 to flow at velocities which are near that of the brush, and maximizes the pressure in the interdental and subgingival regions, beyond the actual reach of the bristles. The dental fluid 56 may be saliva, with additional water or a conventional dentifrice, i.e. toothpaste, or special bacteria-fighting solutions.

[0018] This action of the bristles, briefly described above and in more detail below, results in a number of particular acoustical effects beyond the tips of the bristles themselves. It should be understood, however, that while a significant advantage of the toothbrush of the present invention is in its acoustic cleansing effects, the toothbrush is also capable of scrubbing action, which removes plaque mechanically in those areas where the bristles physically contact the dental plaque. The mechanical erosion of plaque is dependent on the actual distance traveled by the tips of the bristles. In the present invention, the toothbrush works best at relatively light loading (pressure against the teeth). Typically this is about 10% of the loading normally encountered in brushing with conventional brushes. This reduction in loading will decrease the abrasion caused by bristle contact but at the same time facilitate the back and forth fluid movement which is important in achieving the desired acoustic effects.

[0019] The first significant acoustic effect, involving fluid-coupled effects from the movement of the bristles, concerns acoustical pressure on the plaque. Damage to the plaque results from the alternating pressure field in the dental fluid produced by the bristle movement, which is transmitted to the plaque. The plaque is believed to absorb the vibrational energy produced by the bristles, with resulting damage thereto. Further, the vibrational stress in the plaque allows entry of chemically active agents which may be present in the dental fluid into the interior of the plaque, which enhances the effectiveness of such agents. The movement of the bristles creates an alternating pressure field about the teeth while maintaining a bolus of fluid near the bristle tips. When the moving bristles are positioned over the interdental regions, the pressure field created in the fluid by the action of the bristles extends into those regions which are not reached by the bristles themselves.

[0020] The pressure on the fluid, which is forced to flow at the bristle tip velocity, is approximately 9 kPa. The pressure falls off with the cosine of the angle of the direction of bristle movement. The pressure will be focused in line with the bristles, primarily toward the periodontal regions and the interdental gap. The best results are achieved when the brush is positioned such that the bristles sweep into and over the gumline, forcing the fluid to move back and forth over that region ahead of the tips of the bristles. The pressure created by the alternating action of the bristles in the fluid is also transmitted through the tissue area, which is typically 0.5-2.0 mm thick. The pressure field thus actually reaches and disrupts the bacteria within the periodontal pocket to a substantial (up to 50%) extent. The actual pressure produced by the oscillating (reciprocating) bristles can be approximated by the well-known formula for pressure produced by an oscillating sphere.

[0021] A second acoustical effect is the shear stress effect on the bacteria caused by movement of the fluid. Referring to Figure 5, oral plaque forming bacteria, shown generally at 66, will typically have attachment organelles, referred to as fimbrii or pili, which attach the bacteria to the surface 70 of teeth, as well as to each other. Such bacteria are dislodged from teeth surfaces if the shear stress on the bacteria exceeds a critical value. The critical shear stress for various bacteria will vary according to species. Figure 6 shows the relationship between shear stress (τ) and the rate of bacterial dislodgement. It has been discovered that when the shear stress exceeds the critical value, a rapid increase in dislodgement occurs. Typical oral bacteria which are attached to dental surfaces have critical shear stresses in the range of 30-300 Pa. The force to produce the required shear stress is provided by the dental fluid flowing back and forth over the tooth. The action of the bristles forces the fluid to flow at a particular velocity (the velocity of the tips of the bristles) across the surface of the teeth, including along the interdental channel between adjacent teeth, where a bolus of fluid is forced to flow.

[0022] The initial shear stress is quite high, limited by surface imperfections, e.g. 1000 Pa. Eventually, a boundary layer builds up with a resulting decrease in shear force, with values proportional to bristle tip velocity. Shear stress on the plaque increases significantly when abrasive particles are present in the dental fluid near the surface of the teeth. As an example, a particle in the dental fluid which is moving at 2 m/s at a distance of 10 micrometers from the plaque will result in a shear stress of approximately 10,000 Pa on the plaque, even though the particle itself does not actually contact with the plaque. Typically, critical levels of shear stress can be produced on the plaque at distances 2-3 mm from the tips of the bristles with present invention.

[0023] The oscillatory nature of the shear force produced by the vibrating bristles provides added effects in the dislodging or dispersing of attached bacteria. Because the fluid velocity alternates in direction, fatigue is produced in the bacterial attachments. Fatigue fracture of a bacterial bond occurs in proportion to both the level of applied shear force and the number of times the direction of the shear force reverses. Since teeth are brushed only for a relatively short time (the maximum for the entire mouth area is probably about 3 minutes), the higher the frequency of oscillation, the greater the number of times the bacteria will be subjected to the reversing of the direction of the shear force. Accordingly, if the shear force remains the same, a higher frequency will produce fatigue fracture more quickly.

[0024] A third acoustical effect of the present invention occurring beyond the tips of the bristles is the abrasive erosion (Figure 7) created by movement of the bristles (70A) in a dental fluid 72 which also contains abrasive particles 74. The fluid 72 flows back and forth by virtue of the action of the bristle tips, which are typically in relatively light actual contact with plaque layer 77. The fluid moves back and forth with the bristles, as indicated by the solid lines 78 and dotted lines 80. The damage which is caused to plaque 77 increases rapidly with the tip velocity of the bristles, since the rate of impact as well as the momentum of the particles in the dental fluid increases with velocity. It has been discovered that below a particular threshold value of bristle velocity, the impact of the particles results in only an elastic stress on the plaque formation, as opposed to actual damage. Thus, significant erosion, like the other acoustic effects, is dependent upon critical velocity levels.

[0025] In addition, the bristle movement in a fluid with abrasive particles produces a turbulence in the direction of the flow of the fluid. This turbulent flow is characterized by velocity components in all directions within the fluid, such that the plaque layer is hit by abrasive particles from a variety of angles, rather than strictly along the dental surface as would be the case with laminar flow only.

[0026] A fourth significant acoustic effect is produced by the present invention when the bristles rapidly move back and forth, resulting in quantities of air being pulled into the fluid, in a supersaturation effect. This supersaturation effect results in oxygen being present in the fluid around the tips of the bristles significantly above the normal oxygen tension level. This supersaturated fluid then moves into the subgingival regions, for instance, replacing fluid there which may contain very little oxygen. Anaerobic bacteria thrive in those areas, such as the periodontal regions, where there is little or no oxygen present. Significant damage is done to all classes of anaerobic bacteria by the movement of oxygen-containing fluid into those regions. The supersaturation of dental fluid in effect provides a reservoir of oxygen for the periodontal tissues above the normal oxygen tension level, resulting in a longer-term effect on the anaerobic bacteria.

[0027] Typically, the more rapidly the bristles vibrate and the greater the amplitude of vibration, the more significant is the capturing of oxygen within the fluid and the greater the effect on the anaerobic bacteria. When the brush moves transversely to the fluid surface, a vortex action results which pulls air into the fluid, and when the bristles reverse direction, the air is entrained in the fluid. The more rapid the movement, the greater the vortex action. Bubbles of oxygen typically are propelled into crevices and pockets of the teeth, as well as the gingival areas. The oxygen bubbles are propelled with such initial velocity that they propagate 2-3 cm outwardly from the tips of the bristles if unimpeded, so they easily reach periodontal pockets remote from the bristle tips. The higher the bristle velocity, the greater the propulsion effect. While the exposure time necessary for effective action will vary depending upon the amplitude of the bristle action, operating within the ranges discussed below will produce significant results.

[0028] It should be also understood that the dentifrice itself may contain small bubbles of oxygen and/or oxygen-containing agents such as hydrogen peroxide, which results in an increased effect compared to air as the oxygen source by raising the oxygen tension level above that of atmospheric. In addition, certain active ingredients such as sanguarine, alcohol, various fluorides and chlorhexidine can be used in the dentifrice, and are diffused and/or driven into the crevices of the teeth and the periodontal gingival regions. This can aid in preventing tooth decay. Further, the acoustic effects normally produced by the toothbrush of the present invention as described above will disrupt the plaque matrix, allowing effective penetration of the oxygen and/or the dentifrice agent into the bacterial structure. Also, there may well be a synergistic effect on the antibacterial agents when they are used in the pressure field created by the toothbrush of the present invention.

[0029] All of the above-described acoustic effects relative to disruption of plaque occur at pressures less than 10% than that required for vaporous (true) cavitation, which means that the present invention is practical and safe to implement and use at home.

[0030] While the scrubbing effect produced by direct contact between the bristles and the plaque is directly dependent on the velocity of the tips of the bristles, the above-described fluid-coupled effects, specifically acoustical pressure, shear stress, abrasive erosion, and oxygen saturation, increase exponentially with the velocity of the bristles, typically between a power of 1.5 and 2.5, depending on the particular effect. The applicants have further discovered that there is a threshold velocity at which point significant acoustic effects begin to occur. In particular, significant cleansing effects occur beyond the bristle tips when the toothbrush is operating within particular critical parameter boundaries.

[0031] Figure 8 shows the critical operating regions. One axis shows the amplitude of movement of the bristles, while the other axis shows the frequency of the movement of the tips of the bristles. The velocity of the bristles must be greater than a critical threshold value "U_{crit}" in meters/second, in the range of 1.5 - 2.0 meters/second, for the fluid coupled therapeutic effect to be significant. U_{crit} in turn is determined by frequency and amplitude. The diagonal line 98 in Figure 8 corresponds to a U_{crit} of 2.0 m/s (although as indicated above, the actual range for U_{crit} is 1.5 m/s to 2.0 m/s). A frequency of 250 Hz and an amplitude of 2.5 mm, which are typical operating parameters, will be within the triangular region 99, which is the critical operating region in Figure 8. The vertical edge 100 of triangular region 99 corresponds to amplitudes of ± 6 mm, beyond which increases in amplitude becomes impractical, because of limited room in the oral cavity. The horizontal edge 102 of region 99 corresponds to frequencies of 500 Hz, above which increases in frequency are irritating to human hearing and are above the resonant frequency of the bristles. An appropriate frequency range is 40 Hz - 500 Hz and an appropriate amplitude range is 0.5 mm - 6mm.

[0032] The critical region 99 is remote from the operating characteristics of other known power toothbrushes and when the toothbrush of the present invention is operated within this region, significant cleansing effects are achieved beyond the bristle tips. The present invention also produces acoustic pressure levels far above other commercial power toothbrushes. Typically, a threshold acoustic pressure level is 1.5 kPa.

[0033] In addition to the above, the tooth brush will be constructed so that the operating frequency of the bristles is below their resonant frequency, but close enough thereto to permit a bristle amplitude greater than the amplitude of the plate on which the bristles are mounted. Bristle movement is also typically 2-3 times that of the resonance arm. This facilitates driving the bristle tips to the desired velocity without having to drive the coupling elements, such as the resonance arm, the full amplitude of the bristle tips.

[0034] In summary, a range of bristle tip velocities has been discovered, for a power toothbrush, including specific ranges of tip frequency and amplitude, which results in significant therapeutic effects beyond the physical reach of the tips of the bristles, by virtue of the action of the bristles in a surrounding dentifrice fluid.

[0035] Although a preferred embodiment of the invention has been disclosed herein for illustration, it should be understood that various changes, modifications and substitutions may be incorporated in such embodiment without departing from the scope of the protection which is defined by the claims which follow:

Claims

1. A dental hygiene device (10) for cleaning teeth (50,53) and interdental and gingival areas, comprising:

   a body member (12,95) which includes an arm (32) mounted for movement;
   a set of bristles (47,52,70A) having free end tips, the set of bristles (47,52,70A) being located in the vicinity of one end (44) of the arm (32); and
   means (16,26,35 and 36) in the body member (12,95) operable to move the arm (32) and hence the set of bristles (47,52,70A) characterized in that said means (16,26,35 and 36) are operable to move the arm (32) such that the tips of the bristles (47,52,70A) move at a velocity greater than approximately 1.5 meters per second, which is sufficient to produce a cleansing action with a dentifrice fluid (56) beyond the tips of the bristles (47,52,70A).

2. A dental hygiene device (10) according to claim 1, wherein shear stress on dental plaque (77) created by action of the apparatus is greater than 50 Pa at a distance of 2 mm from the tips of the bristles (47,52,70A).

3. An apparatus (10) of claim 1, wherein the bristles (47,52,70A) extend substantially perpendicularly from the arm (32) and wherein the tips of the bristles (47,52,70A) move in a single plane.

4. An apparatus (10) of claim 1, wherein the tips of the bristles are scalloped with each scalloped portion being in the range of 5-8 mm long, with a depth of 1.5-3 mm.

5. A method for cleaning teeth (50,53)and interdental and gingival areas, using a toothbrush apparatus (10) having a moving arm (32) with a set of bristles (47, 52, 70A) at one end thereof, comprising the steps of:

   providing dental fluid (56) in the vicinity of the teeth (50,53) and interdental and gingival areas to be cleaned; and
   moving the arm (32) and hence the bristles (47,52,70A) such that the tips of the bristles (47,52,70A) move through the dental fluid (56) at a velocity greater than approximately 1.5 meters per second, thereby producing a cleansing effect, through corresponding movement of the dental fluid (56), beyond the tips of the bristles (47,52,70A).

6. A device (10) according to claim 1 or a method according to claim 5, wherein the cleansing effect reaches the interdental and gingival areas without the tips of the bristles (47,57,70A) being in the

immediate vicinity thereof.

7. A device (10) according to claim 1 or a method according to claim 5, wherein the frequency of movement of the tips of the bristles (47,52,70A) is between 40 Hz and 500 Hz and wherein the amplitude of movement is within the range of 0.5 mm to 6 mm.

8. A device (10) or method according to claim 7, wherein the frequency is less than the resonant frequency of the bristles (47,52,70A).

9. A device (10) according to claim 1 or a method according to claim 5, wherein movement of the bristles (47,52,70A) produces an acoustic pressure of at least 1.5 kPa.

10. A device (10) according to claim 1 or a method according to claim 5, wherein the motion of said bristles (47,52,70A) is in a single plane, such that when the bristles (47,52,70A) are positioned horizontally against the tooth (50,53), the tips of the bristles (47,52,70A) move vertically toward and away from the gum line.

11. A device (10) according to claim 1 or a method according to claim 5, wherein the set of bristles (47,52,70A) rotates through a preselected arc.

12. A dental hygiene device (10) for cleaning teeth (50,53) and interdental and gingival areas, comprising:

a body member (12,95) which includes an arm (32) mounted for movement;
a set of bristles (47,52,70A) having free end tips, the set of bristles (47,52,70A) being located in the vicinity of one end (44) of the arm (32); and
means (16,26,35 and 36)in the body member (12,95) operable to move the arm (32) and hence the set of bristles (47,52,70A) such that the tips of the bristles (47,52,70A) move at a sufficient velocity to create an alternating pressure field in a dental fluid (56) sufficient that the dental fluid (56) flows in alternate opposing directions at approximately the speed of the bristles (47,52,70A), characterized in that the frequency of movement of the tips of the bristles (47,52,70A)is between 40 Hz and 500 Hz, in that the amplitude of movement of the bristles is within the range of 0.5 mm to 6 mm, and in that the movement of the bristles (47,52,70A) produces an acoustic pressure of at least 1.5 kPa, the alternating pressure field that is created in the dental fluid which is in contact with the teeth (50,53) and the interdental and gingival areas being sufficient to significantly damage dental plaque (77)in the interdental and gingival areas without physical contact between the bristles (47,42,70A) and the plaque (77).

13. A method for cleaning teeth (50,53) and interdental and gingival areas, using a toothbrush apparatus (10) having a moving arm (32) with a set of bristles (47,52,70A) at one end thereof, comprising the steps of:

providing dental fluid (56) in the vicinity of the teeth (50,53) and interdental and gingival areas to be cleaned; and
moving the arm (32) and hence the bristles (47,52,70A) such that the tips of the bristles move (47,52,70A) at a sufficient velocity to create an alternating pressure field in the dental fluid (56) sufficient that the dental fluid (56) flows in alternate opposing directions at approximately the speed of the bristles (47,52,70A), wherein the frequency of movement of the tips of the bristles (47,52,70A) is between 40 Hz and 500 Hz, wherein the amplitude of movement of the bristles (47,52,70A) is within the range of 0.5 mm to 6 mm, and wherein the movement of the bristles (47,57,70A) produces an acoustic pressure of at least 1.5 kPa, the alternating pressure field being sufficient to significantly damage dental plaque (77) without physical contact between the bristles (47,52,70A) and the plaque (77).

14. A dental hygiene device (10) for cleaning teeth (50,53) and interdental and gingival areas, comprising:

a body member (12,95) which includes an arm (32) mounted for movement;
a set of bristles (47,52,70A) having free end tips, the set of bristles (47,52,70A) being located in the vicinity of one end (44) of the arm (32); and
means (16,26,35 and 36) in the body member (12,95) operable to move the arm (32) and hence the set of bristles (47,52,70A) characterized in that said means (16,26,35 and 36) are operable to move the arm (32) such that the tips of the bristles (47,52,70A) move at a frequency between 40 Hz and 500 Hz, such that the amplitude of movement of the bristles (47,52,70A) is within a range of 0.5 mm to 6 mm, and such that the velocity of the tips of the bristles (47,52,70A) is sufficient to produce a shear stress, approximately at least 50 Pa, on bacteria (66) on the teeth (50,53) in the interdental and gingival areas sufficient to dislodge

said bacteria (66) without physical contact between the bristles (47,52,70A) and the bacteria (66).

15. A device (10) according to claim 1 or claim 12, or claim 14 or a method according to claim 5, wherein the velocity of the bristles (47,52,70A) is approximately at least 1.5 meters per second and preferably is greater than 2.0 meters per second.

16. A method for cleaning teeth (50,53) and interdental and gingival areas, using a toothbrush apparatus (10) having a moving arm (32) with a set of bristles (47,52,70A) at one end thereof, comprising the steps of:

providing dental fluid (56) in the vicinity of the teeth (50,53) and interdental and gingival areas to be cleaned; and

moving the arm (32) and hence the bristles (47,52,70A) such that the tips of the bristles (47,52,70A) move at a frequency between 40 Hz and 500 Hz, and wherein the amplitude of movement of the bristles is (47,52,70A) within the range of 0.5 mm to 6 mm, wherein the velocity of the tips of the bristles (47,52,70A) is sufficient to produce shear stress, approximately at least 50 Pa, on bacteria (66) on the teeth (50,53) in the interdental and gingival areas sufficient to dislodge said bacteria (66) without physical contact between the bristles (47,52,70A) and the bacteria (66).

17. A method according to claim 5, or claim 13 or claim 16, wherein the dental fluid (56) contains abrasive particles, which increases the dislodgement of the bacteria (66).

18. A method according to claim 5, or claim 13, or claim 16, wherein the dental fluid (56) contains oxygen-releasing agents.

19. A method according to claim 5, or claim 13, or claim 16, wherein the dental fluid (56) contains an antibacterial agent.

Patentansprüche

1. Zahnputzgerät (10) zum Putzen von Zähnen (50,53) und Zwischenzahn- und Zahnfleischbereichen, mit:

einem Gehäuseteil (12,95), das einen Arm (32) aufweist, der bewegbar angebracht ist;

einem Satz von Borsten (47,52,70A), die freie Endspitzen aufweisen, wobei der Satz von Borsten (47,52,70A) in der Nähe eines Endes (44) des Arms (32) angeordnet ist; und

Einrichtungen (16,26,35 und 36) in dem Körperteil (12,95) die betätigbar sind, um den Arm (32) und somit den Satz von Borsten (47,52,70A) zu bewegen, dadurch gekennzeichnet, daß die Einrichtungen (16,26,35 und 36) betätigbar sind, um den Arm (32) zu bewegen derart, daß die Spitzen der Borsten (47,52,70A) sich mit einer Geschwindigkeit bewegen, die größer ist als ca. 1,5 Meter pro Sekunde, was ausreicht um einen Putzvorgang mit einer Zahnputzflüssigkeit (56) über die Spitzen der Borsten (47,52,70A) hinaus zu erzeugen.

2. Zahnputzgerät (10) nach Anspruch 1, bei dem eine Scherbeanspruchung auf den Zahnbelag (77), die durch den Betrieb des Geräts erzeugt wird, größer ist als 50 Pa in einem Abstand von 2 mm von den Spitzen der Borsten (47,52,70A).

3. Gerät (10) nach Anspruch 1, wobei die Borsten (47,52,70A) sich im wesentlichen senkrecht von dem Arm (32) erstrecken, und wobei die Spitzen der Borsten (47,52,70A) sich in einer einzigen Ebene bewegen.

4. Gerät (10) nach Anspruch 1, wobei die Spitzen der Borsten bogen- oder zahnförmig ausgeschnitten sind, wobei jeder ausgebogene oder ausgeschnittene Abschnitt im Bereich von 5-8 mm Länge von 1,5-3 mm Tiefe liegt.

5. Verfahren zum Putzen von Zähnen (50,53) und Zwischenzahn- und Zahnfleischbereichen, unter Verwendung eines Zahnputzgeräts (10), das einen bewegbaren Arm (32) mit einem Satz von Borsten (47,52,70A) an einem seiner Enden aufweist, welches die folgenden Schritte aufweist:

Zuführen von Zahnputzflüssigkeit (56) in die Nähe der Zähne (50,53) und den Zwischenzahn- und Zahnfleischbereichen, die gereinigt werden sollen; und

Bewegen des Arms (32) und somit der Borsten (47,52,70A), derart, daß die Spitzen der Borsten (47,52,70A) sich durch die Zahnputzflüssigkeit (56) mit einer Geschwindigkeit bewegen, die größer ist als annähernd 1,5 Meter pro Sekunde, wodurch ein Reinigungseffekt erzeugt wird, durch eine entsprechende Bewegung der Zahnputzflüssigkeit (56) über die Spitzen der Borsten (47,52,70A) hinaus.

6. Gerät (10) nach Anspruch 1, oder Verfahren nach Anspruch 5, wobei der Reinigungs- bzw. Säube-

rungseffekt die Zwischenzahn- und Zahnfleischbereiche erreicht, ohne daß sich die Spitzen der Borsten (47,52,70A) in der unmittelbaren Nachbarschaft davon befinden.

7. Gerät (10) nach Anspruch 1, oder Verfahren nach Anspruch 5, wobei die Bewegungsfrequenz der Spitzen der Borsten (47,52,70A) zwischen 40 Hz und 500 Hz liegt und wobei die Bewegungsamplitude innerhalb des Bereichs von 0,5 mm bis 6 mm liegt.

8. Gerät (10) oder Verfahren nach Anspruch 7, wobei die Frequenz geringer ist als die Resonanzfrequenz der Borsten (47,52,70A).

9. Gerät (10) nach Anspruch 1 oder Verfahren nach Anspruch 5, wobei die Bewegung der Borsten (47,52,70A) einen Schalldruck von wenigstens 1,5 kPa erzeugt.

10. Gerät (10) nach Anspruch 1 oder Verfahren nach Anspruch 5, wobei die Bewegung der Borsten (47,52,70A) in einer einzigen Ebene erfolgt, derart, daß, wenn die Borsten (47,52,70A) horizontal gegen den Zahn (50,53) ausgerichtet sind, sich die Spitzen der Borsten (47,52,70A) vertikal zu und weg von der Zahnfleischlinie bewegen.

11. Gerät (10) nach Anspruch 1 oder Verfahren nach Anspruch 5, wobei der Satz von Borsten (47,52,70A) sich über einen vorgewählten Bogen dreht.

12. Zahnputzgerät (10) zum Putzen von Zähnen (50,53) und Zwischenzahn- und Zahnfleischbereichen, mit:

einem Körperteil (12,95), das einen Arm (32) umfaßt, der beweglich angebracht ist;

einem Satz von Borsten (47,52,70A), der freie Spitzenenden aufweist, wobei der Satz von Borsten (47,52,70A) in der Nähe eines Endes (44) des Arms (32) angeordnet ist; und

Einrichtungen (16,26,35 und 36) in dem Körperteil (12,95), die betätigbar sind, um den Arm (32) und damit den Satz von Borsten (47,52,70A) zu bewegen, derart, daß sich die Spitzen der Borsten (47,52,70A) mit einer ausreichenden Geschwindigkeit bewegen, um ein alternierendes Druckfeld in einer Zahnputzflüssigkeit (56) zu erzeugen, das ausreicht, daß die Zahnputzflüssigkeit (56) in alternierende entgegengesetzte Richtungen mit annähernd der Geschwindigkeit der Borsten (47,52,70A) fließt, dadurch gekennzeichnet, daß die Bewegungsfrequenz der Spitzen der Borsten (47,52,70A) zwischen 40 Hz und 500 Hz liegt, daß die Bewegungsamplitude der Borsten in einem Bereich von 0,5 mm bis 5 mm liegt, und daß die Bewegung der Borsten (47,52,70A) einen Schalldruck von wenigstens 1,5 kPa erzeugt, wobei das alternierende Druckfeld, das in der Zahnputzflüssigkeit erzeugt wird, die in Kontakt mit den Zähnen (50,53) und den Zwischenzahn- und Zahnfleischbereichen steht, ausreichend ist, um signifikant den Zahnstein (77) in den Zwischenzahn- und Zahnfleischbereichen, ohne physischen Kontakt zwischen den Borsten (47,52,70A) und dem Zahnstein (77), zu zerstören.

13. Verfahren zum Putzen von Zähnen (50,53) und Zwischenzahn- und Zahnfleischbereichen, unter Verwendung eines Zahnputzgeräts (10), das einen beweglichen Arm (32) mit einem Satz von Borsten (47,52,70A) an einem seiner Enden aufweist, wobei es die folgenden Schritte aufweist:

Liefern von Zahnputzflüssigkeit (56) in die Nachbarschaft der Zähne (50,53) und der Zwischenzahn- und Zahnfleischbereiche, die zu reinigen sind; und

Bewegen des Arms (32) und somit der Borsten (47,52,70A) derart, daß die Spitzen der Borsten (47,52,70A) sich bei einer ausreichenden Geschwindigkeit bewegen, um ein alternierendes Druckfeld in der Zahnputzflüssigkeit (56) zu erzeugen, das ausreicht, daß die Zahnputzflüssigkeit (56) in abwechselnden entgegengesetzten Richtungen mit ungefähr der Geschwindigkeit der Borsten (47,52,70A) fließt, wobei die Bewegungsfrequenz der Spitzen der Borsten (47,52,70A) zwischen 40 Hz und 500 Hz liegt, wobei die Bewegungsamplitude der Borsten (47,52,70A) in einem Bereich von 0,5 mm bis 6 mm liegt, wobei die Bewegung der Borsten (47,52,70A) einen Schalldruck von wenigstens 1,5 kPa erzeugt, wobei das abwechselnde, bzw. alternierende Druckfeld ausreicht, um eine signifikante Zerstörung von Zahnstein (77) ohne physischen Kontakt zwischen den Borsten (47,52,70A) und dem Zahnstein (77) zu erzeugen.

14. Zahnputzgerät (10) zum Putzen von Zähnen (50,53) und Zwischenzahn- und Zahnfleischbereichen, mit:

einem Körperteil (12,95) der einen Arm (32) aufweist, der bewegbar angebracht ist;

einem Satz von Borsten (47,52,70A) die freie

Spitzenenden aufweisen, wobei der Satz von Borsten (47,52,70A) in der Nachbarschaft eines Endes (44) des Arms (32) angeordnet ist; und

Einrichtungen (16,26,35 und 36) in dem Körperteil (12,95), die betätigbar sind, um den Arm (32) und somit den Satz von Borsten (47,52,70A) zu bewegen, dadurch gekennzeichnet, daß die Einrichtung (16,26,35 und 36) betätigbar sind, um den Arm (32) derart zu bewegen, daß die Spitzen der Borsten (47,52,70A) sich bei einer Frequenz zwischen 40 Hz und 500 Hz bewegen, derart, daß die Bewegungsamplitude der Borsten (47,52,70A) sich in einem Bereich von 0,5 mm bis 6 mm befindet, und derart, daß die Geschwindigkeit der Spitzen der Borsten (47,52,70A) ausreichend ist, um eine Abscher- oder Brechspannung oder -beanspruchung von ungefähr wenigstens 50 Pa auf Bakterien (66) auf den Zähnen (50,53) in den Zwischenzahn- und Zahnfleischbereichen zu erzeugen, die ausreicht, um die Bakterien (66) ohne physischen Kontakt zwischen den Borsten (47,52,70A) und den Bakterien (66) loszulösen bzw. zu entfernen.

15. Gerät (10) nach Anspruch 1 oder Anspruch 12 oder Anspruch 14 oder einem Verfahren nach Anspruch 5, wobei die Geschwindigkeit der Borsten (47,52,70A) ungefähr wenigstens 1.5 Meter pro Sekunde und bevorzugt größer als 2,0 Meter pro Sekunde beträgt.

16. Verfahren zum Putzen von Zähnen (50,53) und Zwischenzahn- und Zahnfleischbereichen, unter Verwendung eines Zahnputzgeräts (10), das einen bewegbaren Arm (32) mit einem Satz von Borsten (47,52,70A) an einem Ende davon aufweist, wobei es die folgenden Schritte aufweist:

Zuführen von Zahnputzflüssigkeit (56) in die Nähe der Zähne (50,53) und der Zwischenzahn- und Zahnfleischbereiche, die gereinigt bzw. geputzt werden sollen; und

Bewegen des Arms (32) und somit der Borsten (47,52,70A) derart, daß die Spitzen der Borsten (47,52,70A) sich bei einer Frequenz zwischen 40 Hz und 500 Hz bewegen, und wobei die Bewegungsamplitude der Borsten (47,52,70A) innerhalb des Bereiches von 0.5 mm bis 6 mm liegt, wobei die Geschwindigkeit der Spitzen der Borsten (47,52,70A) ausreicht, um eine Abscher- oder Brechbeanspruchung von ungefähr wenigstens 50 Pa auf Bakterien (66) auf den Zähnen (50,53) in den Zwischenzahn- und Zahnfleischbereichen zu erzeugen, die ausreicht, die Bakterien (66) ohne physischen Kontakt zwischen den Borsten (47,52,70A) und den Bakterien (66) abzulösen bzw. zu entfernen.

17. Verfahren nach Anspruch 5 oder Anspruch 13 oder Anspruch 16, wobei die Zahnputzflüssigkeit (56) Abreibpartikel enthält, die das Entfernen der Bakterien (66) erhöht.

18. Verfahren nach Anspruch 5, Anspruch 13 oder Anspruch 16, wobei die Zahnputzflüssigkeit (56) Sauerstoff freisetzende Zusätze enthält.

19. Verfahren nach Anspruch 5, Anspruch 13 oder Anspruch 16, wobei die Zahnputzflüssigkeit (56) einen antibakteriellen Zusatz enthält.

Revendications

1. Dispositif (10) d'hygiène dentaire pour nettoyer des dents (50, 53) et des zones inter-dentaires et gingivales, comportant :

un élément (12, 95) formant corps qui inclut un bras (32) monté pour un déplacement ;
un ensemble de poils (47, 52, 70A) de brosserie ayant des pointes d'extrémité libres, l'ensemble de poils (47, 52, 70A) de brosserie étant situé au voisinage d'une extrémité (44) du bras (32) ; et
des moyens (16, 26, 35 et 36) dans l'élément (12, 95) formant corps pouvant fonctionner pour déplacer le bras (32) et par conséquent l'ensemble de poils (47, 52, 70A) de brosserie, caractérisé en ce que les moyens (16, 26, 35 et 36) peuvent fonctionner pour déplacer le bras (32) de sorte que les pointes des poils (47, 52, 70A) de brosserie se déplacent à une vitesse plus grande qu'approximativement 1,5 mètre par seconde, ce qui est suffisant pour produire une action de nettoyage avec un fluide (56) dentifrice au-delà des pointes des poils (47, 52, 70A) de brosserie.

2. Dispositif (10) d'hygiène dentaire suivant la revendication 1, dans lequel la contrainte en cisaillement sur la plaque (77) dentaire créée par l'action du dispositif est supérieure à 50 Pa à une distance de 2 mm des pointes des poils (47, 52, 70A) de brosserie.

3. Dispositif (10) suivant la revendication 1, dans lequel les poils (47, 52, 70A) de brosserie s'étendent sensiblement perpendiculairement à partir du bras (32) et dans lequel les pointes des poils (47, 52, 70A) de brosserie se déplacent dans un unique

plan.

4. Dispositif (10) suivant la revendication 1, dans lequel les pointes des poils de brosserie sont échancrées, chaque partie échancrée ayant une longueur comprise dans le domaine de 5 à 8 mm, avec une profondeur de 1,5 à 3 mm.

5. Procédé pour nettoyer des dents (50, 53) et des zones inter-dentaires et gingivales, en utilisant un dispositif (10) de brossage de dents ayant un bras (32) mobile ayant un ensemble de poils (47, 52, 70A) de brosserie à une de ses extrémités, comportant les étapes qui consistent à :

   fournir du fluide (56) de dentifrice au voisinage des dents (50, 53) et des zones inter-dentaires et gingivales à nettoyer ; et
   déplacer le bras (32) et par conséquent les poils (47, 52, 70A) de brosserie de sorte que les pointes des poils (47, 52, 70A) de brosserie se déplacent dans le fluide (56) de dentifrice à une vitesse supérieure à approximativement 1,5 mètre par seconde, pour ainsi produire un effet de nettoyage, par un déplacement correspondant du fluide (56) de dentifrice, au-delà des pointes des poils (47, 52, 70A) de brosserie.

6. Dispositif (10) suivant la revendication 1, ou procédé suivant la revendication 5, dans lequel l'effet de nettoyage atteint les zones inter-dentaires et gingivales sans que les pointes des poils (47, 52, 70A) de brosserie ne se trouvent au voisinage immédiat de celles-ci.

7. Dispositif (10) suivant la revendication 1, ou procédé suivant la revendication 5, dans lequel la fréquence de déplacement des pointes des poils (47, 52, 70A) de brosserie est comprise entre 40 Hz et 500 Hz et dans lequel l'amplitude de déplacement est comprise dans le domaine de 0,5 mm à 6 mm.

8. Dispositif (10) ou procédé suivant la revendication 7, dans lequel la fréquence est inférieure à la fréquence de résonance des poils (47, 52, 70A) de brosserie.

9. Dispositif (10) suivant la revendication 1 ou procédé suivant la revendication 5, dans lequel le déplacement des poils (47, 52, 70A) de brosserie produit une pression acoustique d'au moins 1,5 kPa.

10. Dispositif (10) suivant la revendication 1 ou procédé suivant la revendication 5, dans lequel le déplacement des poils (47, 52, 70A) de brosserie se trouve dans un plan unique, de sorte que lorsque les poils (47, 52, 70A) de brosserie sont positionnés horizontalement contre les dents (50, 53), les pointes des poils (47, 52, 70A) de brosserie se déplacent verticalement en direction de la ligne des gencives et en s'éloignant de la ligne des gencives.

11. Dispositif (10) suivant la revendication 1 ou procédé suivant la revendication 5, dans lequel l'ensemble des poils (47, 52, 70A) de brosserie tourne sur un arc présélectionné.

12. Dispositif (10) d'hygiène dentaire pour nettoyer des dents (50, 53) et des zones inter-dentaires et gingivales, comportant :

   un élément (12, 95) formant corps qui inclut un bras (32) monté pour un déplacement ;
   un ensemble de poils (47, 52, 70A) de brosserie ayant des pointes d'extrémité libres, l'ensemble des poils (47, 52, 70A) de brosserie étant situé au voisinage d'une extrémité (44) du bras (32) ; et
   des moyens (16, 26, 35 et 36) dans l'élément (12, 95) formant corps pouvant fonctionner pour déplacer le bras (32) et par conséquent l'ensemble des poils (47, 52, 70A) de brosserie de sorte que les pointes des poils (47, 52, 70A) de brosserie se déplacent à une vitesse suffisante pour créer un champ alternatif de pression dans un fluide (56) de dentifrice suffisant pour que le fluide (56) de dentifrice s'écoule dans les directions opposées alternées approximativement à la vitesse des poils (47, 52, 70A) de brosserie, caractérisé en ce que la fréquence de déplacement des pointes des poils (47, 52, 70A) de brosserie est comprise entre 40 Hz et 500 Hz, en ce que l'amplitude de déplacement des poils de brosserie est comprise dans le domaine de 0,5 mm à 6 mm, et en ce que le déplacement des poils (47, 52, 70A) de brosserie produit une pression acoustique d'au moins 1,5 kPa, le champ de pression alternatif qui est créé dans le fluide de dentifrice qui est en contact avec les dents (50, 53) et les zones interdentaires et gingivales étant suffisant pour endommager de manière significative la plaque (77) dentaire dans les zones inter-dentaires et gingivales sans contact physique entre les poils (47, 52, 70A) de brosserie et la plaque (77).

13. Procédé pour nettoyer des dents (50, 53) et des zones inter-dentaires et gingivales, en utilisant un dispositif (10) de brossage de dents ayant un bras (32) mobile ayant un ensemble de poils (47, 52, 70A) de brosserie à une de ses extrémités, comportant les étapes qui consistent à :

   prendre du fluide (56) de dentifrice pour le met-

tre au voisinage des dents (50, 53) et des zones interdentaires et gingivales à nettoyer ; et

déplacer le bras (32) et par conséquent les poils (47, 52, 70A) de brosserie de sorte que les pointes des poils de brosserie se déplacent (47, 52, 70A) à une vitesse suffisante pour créer un champ de pression alternatif dans le fluide (56) de dentifrice qui sera suffisant pour que le fluide (56) de dentifrice s'écoule suivant des directions opposées alternées approximativement à la vitesse des poils (47, 52, 70A) de brosserie, dans lequel la fréquence de déplacement des pointes des poils (47, 52, 70A) de brosserie est comprise entre 40 Hz et 500 Hz, dans lequel l'amplitude de déplacement des poils (47, 52, 70A) de brosserie est comprise dans le domaine de 0,5 mm et 6 mm, et dans lequel le déplacement des poils (47, 52, 70A) de brosserie produit une pression acoustique d'au moins 1,5 kPa, le champ de pression alternatif étant suffisant pour endommager significativement la plaque (77) dentaire sans contact physique entre les poils (47, 52, 70A) de brosserie et la plaque (77).

14. Dispositif (10) d'hygiène dentaire pour nettoyer des dents (50, 53) et des zones inter-dentaires et gingivales, comportant :

un élément (12, 95) formant corps qui inclut un bras (32) monté pour le déplacement ;
un ensemble de poils (47, 52, 70A) de brosserie ayant des pointes d'extrémité libres, l'ensemble de poils (47, 52, 70A) de brosserie étant situé au voisinage d'une extrémité (44) du bras (32) ; et
des moyens (16, 26, 35 et 36) dans l'élément (12, 95) formant corps pouvant fonctionner pour déplacer le bras (32) et par conséquent l'ensemble des poils (47, 52, 70A) de brosserie caractérisé en ce que les moyens (16, 26, 35 et 36) peuvent fonctionner pour déplacer le bras (32) de sorte que les pointes des poils (47, 52, 70A) de brosserie se déplacent à une fréquence comprise entre 40 Hz et 500 Hz, de sorte que l'amplitude de déplacement des poils (47, 52, 70A) de brosserie est comprise dans un domaine de 0,5 mm à 6 mm, et de sorte que la vitesse des pointes des poils (47, 52, 70A) de brosserie est suffisante pour produire une contrainte de cisaillement, approximativement au moins 50 Pa, sur des bactéries (66) sur les dents (50, 53) dans les zones inter-dentaires et gingivales suffisante pour déloger les bactéries (66) sans qu'il y ait contact physique entre les poils (47, 52, 70A) de brosserie et les bactéries (66).

15. Dispositif (10) suivant la revendication 1 ou 12, ou la revendication 14 ou procédé suivant la revendication 5, dans lequel la vitesse des poils (47, 52, 70A) de brosserie est approximativement d'au moins 1,5 mètre par seconde et de préférence supérieure à 2 mètres par seconde.

16. Procédé pour nettoyer des dents (50, 53) et des zones inter-dentaires et gingivales, en utilisant un dispositif (10) de brossage de dents ayant un bras (32) mobile ayant un ensemble de poils (47,52, 70A) de brosserie à une de ses extrémités, comprenant les étapes qui consistent à :

mettre du fluide (56) de dentifrice au voisinage de la dent (50, 53) et des zones inter-dentaires et gingivales à nettoyer ; et
déplacer le bras (32) et par conséquent les poils (47, 52, 70A) de brosserie de sorte que les pointes des poils (47, 52, 70A) de brosserie se déplacent à une fréquence comprise entre 40 Hz et 500 Hz, et dans lequel l'amplitude de déplacement des poils de brosserie est (47, 52, 70A) comprise dans le domaine de 0,5 mm à 6 mm, dans lequel la vitesse des pointes des poils (47, 52, 70A) de brosserie est suffisante pour produire une contrainte en cisaillement, approximativement au moins 50 Pa, sur des bactéries (66) sur les dents (50, 53) dans les zones interdentaires et gingivales qui sera suffisante pour déloger les bactéries (66) sans qu'il y ait contact physique entre les poils (47, 52, 70A) de brosserie et les bactéries (66).

17. Procédé suivant la revendication 5, ou la revendication 13 ou la revendication 16, dans lequel le fluide (56) de dentifrice contient des particules abrasives, qui augmentent la dislocation des bactéries (66).

18. Procédé suivant la revendication 5, ou la revendication 13 ou la revendication 16, dans lequel le fluide (56) de dentifrice contient des agents de libération d'oxygène.

19. Procédé suivant la revendication 5, ou la revendication 13 ou la revendication 16, dans lequel le fluide (56) de dentifrice contient un agent anti-bactérien.

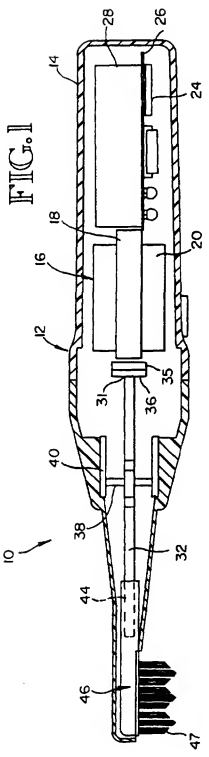


FIG. 1

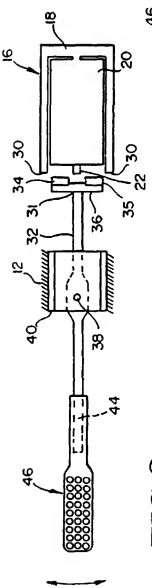


FIG. 2

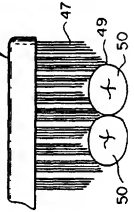


FIG. 3

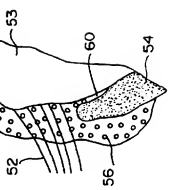


FIG. 4

FIG. 5

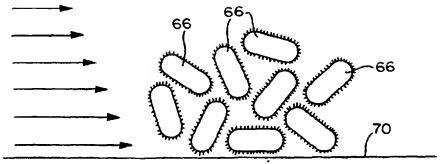


FIG. 6

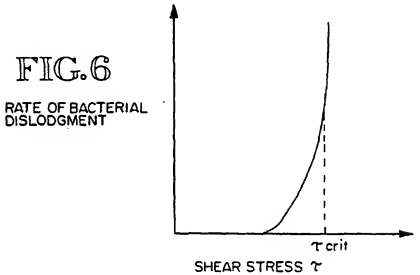


FIG. 7

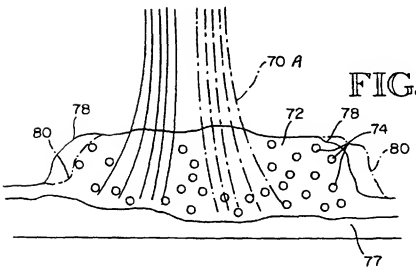


FIG. 8

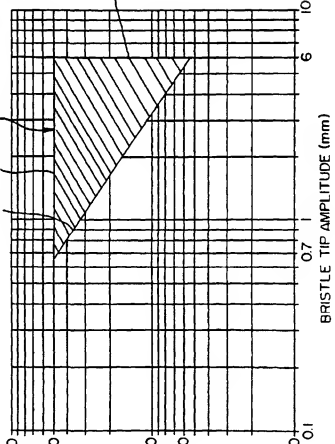
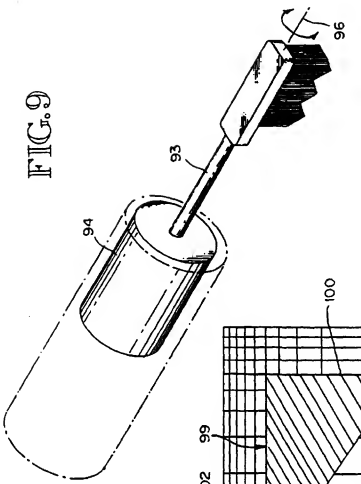

1000
500
100
60
10
0.1
FREQUENCY Hz
98
102
99
100
10
6
1
0.7
BRISTLE TIP AMPLITUDE (mm)

FIG. 9


94
93
96